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Occupant productivity and indoor environment quality: A case of GSAS

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Abstract

Purpose: The purpose of the paper is to establish links between Indoor Environment Quality (IEQ) factors that affect occupant productivity and Global Sustainability Assessment System (GSAS) building rating system. The paper analyses the current state of GSAS using a desktop study, survey and brainstorming session organised in a workshop with GSAS Certified Green Professionals (CGP).

Methodology/design/approach: The study was conducted in three steps. First, a comprehensive literature review was conducted to identify IEQ factors that influence occupant productivity in offices. The second step was a desktop analysis of current GSAS building rating system to identify criteria and submittals that may help to increase occupant productivity. It was followed by a facilitated workshop of GSAS CGPs that included a survey and a brainstorming session to highlight the current state of GSAS rated building performances on occupant productivity. The workshop was attended by 41 CGPs in Doha, Qatar.

Findings: The paper highlighted that GSAS needs to be updated to increase occupant productivity in GSAS rated buildings. A periodic post-occupancy survey in GSAS buildings should be mandated to ensure better occupant productivity. The paper also presented various methods to make GSAS rated buildings more occupant-friendly.

Originality/value: This study is the first study to analyse green building guidelines in the context of occupant productivity, especially in Qatar.

Keywords: Green building rating system; Indoor environment quality; Occupant productivity; Sustainability

1. Introduction

Humans have endeavoured for centuries to create comfortable and secure habitat. This effort to create comfortable habitat has led to industrial and technological

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progress leading to a current state of various complex and robust building structures used for various purposes. In most of the industrialised countries, humans spend about 80–90% of their time indoors (Ashrae, 1993, Höppe, 2002). The industrialisation and development of built environment sector led to higher energy consumption and Green House Gas (GHG) emissions. The built environment sector accounts for 40% of the global energy use and more than one-third of global GHG emissions (UNEP, 2009, Sinha et al., 2016, Omer, 2008). It led to the development various green building guidelines that focus on reducing the energy consumption and carbon footprint of the built environment (Bre, 2007, Turner et al., 2008). The sustainability efforts are primarily focused towards environmental aspects and economic aspects. The sustainability efforts in built environment industry haven't emphasised on the design and operation implications of any built space on human productivity, well-being and behaviour. The economic aspects are primarily focused on reducing building energy cost by using efficient design, material and operating systems. However, there is little interest in improving the operation cost apart from energy cost of the building, especially in commercial buildings. The operation cost of an organisation includes personnel costs, material costs, financial costs and building related costs (Feige et al., 2013). A study highlights that 25 years of companies' personnel costs represent 85% of the total operational cost (Cabe, 2005). A nationwide study in the UK indicated that good office environment could help to increase productivity up to 20%, equivalent to £135 bn per year (Wheeler et al., 2006). The indoor environment has a significant impact on health and well-being of the occupants. Healthy and conducive buildings lead to happy and productive occupants (Mendell et al., 2002). A vast research directs that good indoor environment quality in a workplace can help to reduce employee absenteeism, staff turnover and increase occupant productivity and satisfaction. Thus, helping to improve health and well-being of their occupant (Al Horr et al., 2016a,b, Heerwagen, 2000, Wyon, 2004, Wargocki et al., 2000, Tse and So, 2007, Oseland and Bartlett, 1999, Miller et al., 2009, Mawson, 2002). It has to be noted that occupants also have a significant influence on building performance. The occupant input and behaviour is a crucial factor in the performance of building operation technologies and systems. Occupant interactions with the building are not always positive, especially in the case of energy consumption (Harris, 2012). Lack of comfort, physiological satisfaction leads to human interactions with heating, ventilation and air-conditioning system of the building. A carefree attitude or wrong actions can lead to failings in the energy efficient systems of a building. A study of 121 LEED-rated buildings highlighted that 30% performed better than expected, 25% performed worse than anticipated, and few had serious energy consumption patterns (Hauge et al., 2010, Turner and Frankel, 2008). It highlights the complex relationship between indoor environment quality and occupant comfort, health and productivity. A bad indoor environment leads to uncomfortable and unsatisfied occupants. These occupants' negative interaction with building's operation may lead to energy efficiency losses and poor building performance. All this evidence highlights the need to emphasises the importance of understanding IEQ and its relationship to occupant productivity. The green building guidelines have the aim of making the built environment more sustainable. Occupant health, productivity and behaviour need to be investigated and incorporated into the categories and criteria of green building guidelines across the globe. This research study aims to investigate the current state of Global Sustainable Assessment System (GSAS) highlighting its current focus on occupant productivity. The research study has following objectives:

(1) To identify indoor environment quality factors that influence occupant productivity in an office environment.
(2) To analyse GSAS building rating system to highlight its current focus on occupant productivity using desktop analysis.
(3) To collect GSAS certified green professionals experience, opinion and perspective on the current state of GSAS using survey method and facilitated brainstorming sessions.
(4) To analyse the findings from GSAS analysis (desktop study), survey and brainstorming sessions and discuss the outcomes and future recommendations.

The rest of the paper is divided into six sections. The first section describes the methodology of the research study. The second section presents the literature review on various IEQ factors that influence occupant productivity. It lists and describes these IEQ factors. The third section presents the analysis of GSAS building rating system (desktop study). It highlights the GSAS criteria and submittals that are related to factors that influence occupant productivity. The fourth section elaborates the workshop results. It discusses the survey results and presents the facilitated brainstorming highlights. The fifth section discusses the results from GSAS analysis and workshop results. The sixth section presents the conclusion and future recommendation of the study.

2. Methodology

The research study aims to analyse GSAS rating system and establish links between its current criteria with occupant productivity and indoor environment quality. The research was conducted in four steps (Fig. 1).

1. To identify indoor environment quality factors that influence occupant productivity in an office environment.The research team conducted a comprehensive literature review to identify the indoor environment

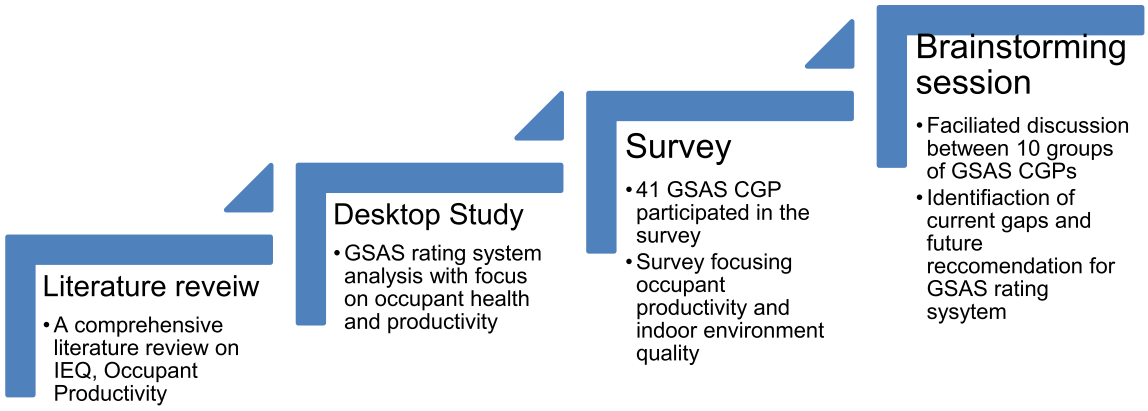

Fig. 1. Research methodology.

quality factors that influence occupant productivity. Literature review leads to the identification of six IEQ factors that influence occupant health and productivity.

2. To analyse GSAS building rating system to highlighting its current focus on occupant productivity using desktop analysis.The research team conducted a desktop study to critically analyse the criteria and submittals of GSAS building rating system. The analysis identified various criteria and submittals under each IEQ factor that affect occupant productivity.
3. To collect GSAS certified green professionals experience, opinion and perspective on the current state of GSAS using survey method and facilitated brainstorming sessions.A facilitated workshop was organised in Doha, Qatar. 41 GSAS certified green professionals participated in the workshop. A presentation focusing occupant productivity was delivered. The presentation highlighted the importance of occupant comfort, productivity and various indoor environment quality factors that affect it. The presentation helped to focus the participants' thoughts on the areas of indoor environment quality, occupant comfort and productivity and green building ratings. Circulation of survey instrument followed it. The participants were given an hour to complete the survey. A 15-min break followed it. The brainstorming session was conducted after the break.
4. To analyse the findings from GSAS analysis (desktop study), survey and brainstorming sessions and discuss the outcomes and future recommendations.The research team collated all the data from survey and brainstorming session and GSAS analysis. All the findings were analysed to outline the positive aspects, gaps and future recommendations of GSAS rating system.

2.1. Development of the survey instrument

a. Survey: The survey aimed to collect industry professionals' experience; opinions on GSAS rated building and their performance focusing occupant comfort and productivity. The workshop participants were requested to fill a survey that included a range of questions about IEQ, occupant productivity and health and wellbeing. The survey instrument was developed after performing a review of the literature on occupant productivity, indoor environment quality and green building practices. It included questions about their work profile and their experience in delivering GSAS certified buildings. The survey also collected information about the performance of six IEQ factors of GSAS rated buildings and their experience on occupants' response to GSAS rated buildings.

b. Facilitated brainstorming session: The brainstorming session was aimed to initiate a more insightful and interactive session focusing the current state of sustainability guidelines, the importance of occupant comfort and productivity, and innovative ways to achieve it. While forming the groups, it was ensured that professionals from all background were evenly distributed in the groups. Architect, Green Building Consultants, Project Managers, Engineers, Operation Managers were present in each group. Each group was given two questions with one hour to discuss and develop their answers/opinions.

The profile of participants was collected using survey:

1) Academic Qualification: More than half of the participants hold bachelor's degree and rest of them holding Master's Degree and two PhD holders (Fig. 2).
2) Professional role in the organisation: Almost half of the participants were project managers or project director in their organisations. The rest of the group was majorly formed Green Building Consultants, Architect, Construction Managers, Design Managers and Mechanical, Electrical and Plumbing (MEP) Engineers/Consultants (Fig. 3).
3) Age profile: The age profile suggests that majority of the participants were between the age of 31 and 40. The second highest number of age group is for participants over 50-year old. The 41–50-year-old group

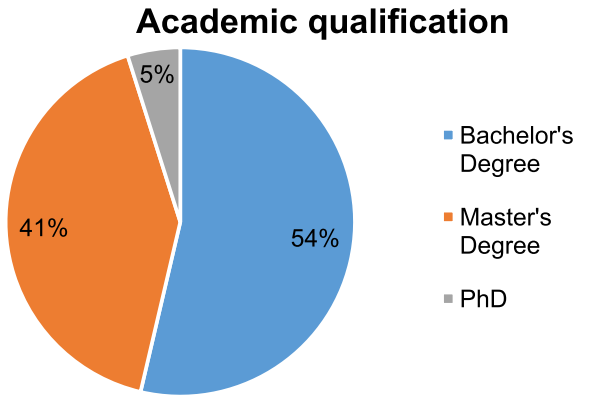

Fig. 2. Academic qualification of participants.

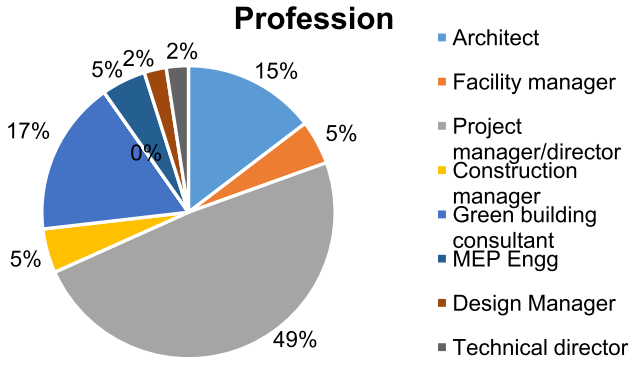

Fig. 3. Profession/profile of participants.

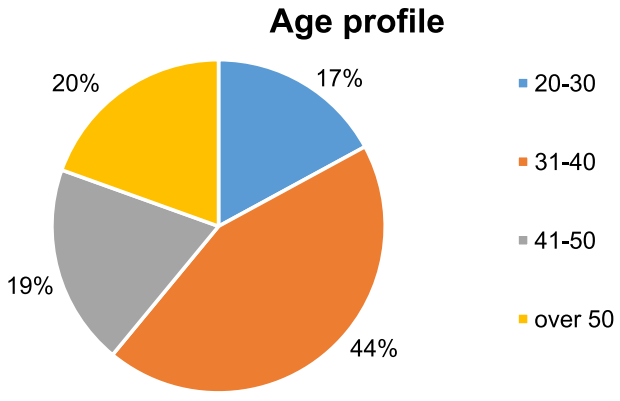

Fig. 4. Age profile of participants.

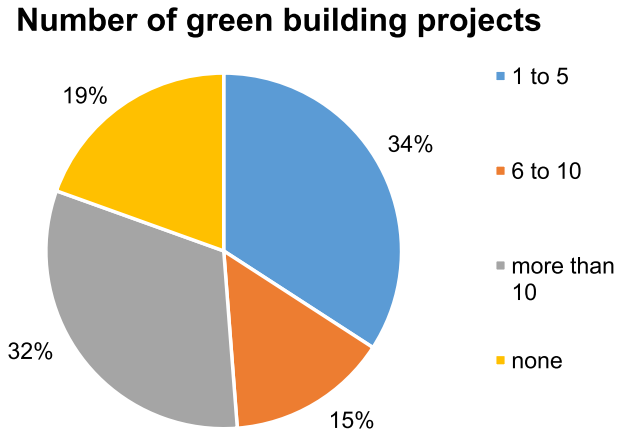

Fig. 5. Green building project experience of participants.

stands third. The lowest number is by 20–30 age group. It indicates that participants profile is from wide age group and has the majority of seasoned professionals (Fig. 4).

4) Number of green building projects: The survey also collected data on the experience of green building projects. Almost one-third of the participants had worked on more than ten projects. Similarly, another one-third have experience of up to five projects. About one-fifth of the participants are new to the industry. This analysis reflects the broad range of experience of the participants. The opinions and answers would incorporate the new and fresh ideas from early career professionals and experienced suggestions from seasoned professionals with a high number of green building projects experience (Fig. 5).
5) Types of green building projects: The participating professionals' experience includes a wide spectrum of projects. It includes residential, commercial, retail, healthcare, warehouse, rail and hospitality, educational. Almost one-third of participants had experience in commercial buildings. The second highest is residential, followed by retail. The data also reflects that implementation of GSAS rating system is very diverse and almost all types of buildings are using GSAS rating system (Fig. 6).

3. Indoor environment quality and occupant productivity

The relationship between indoor environment quality and occupant productivity has been discussed by several researchers (Heerwagen, 2000, Romm and Browning, 1994, Clements-Croome, 2006, 2000). Green building councils across the globe acknowledge the importance of occupant productivity. Overall there is sense awareness about the impact of IEQ factors on occupant productivity. However, there is a lack of focus to address this issue and achieve better green buildings performance in occupant productivity (Potbhare et al., 2009). The literature review aimed to identify these factors and understand their impact on occupant productivity.

The research team conducted a comprehensive literature review to identify the factors that affect occupant productivity (Al Horr et al., 2016b). It led to the identification of eight physical components that affect occupant satisfaction and productivity in an office environment. The team used six most relevant factors in this study.

1. **Indoor Air Quality and Ventilation** (Vernon and Bedford, 1926, Wargocki et al., 2000, Fanger, 1988, Fisk et al., 2012) Indoor air quality represents the degree

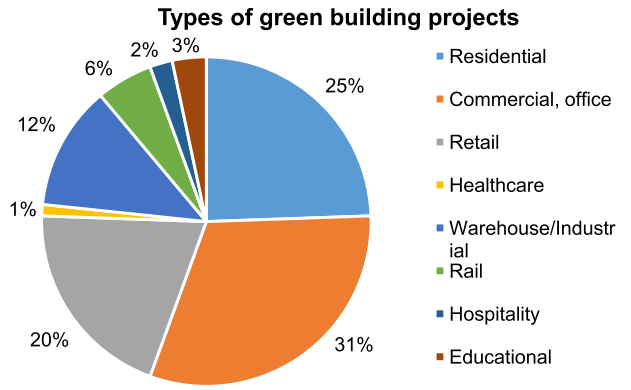

Fig. 6. Types of green building projects.

of quality of air in an indoor environment. It can be either managed by increasing the ventilation of the indoor environment or by reducing the air pollutant load in the air(Al Horr et al., 2016b). Ventilation is used to exchange the indoor air for removing contaminants and carbon dioxide in the indoor air (Seppänen et al., 1999). The literature review has indicated a strong link between poor human health and productivity and prevalence of poor indoor air quality (Satish et al., 2012, Fisk, 2000a,b).

2. **Thermal Comfort** (Fanger, 1970, de Dear et al., 1997, Tanabe et al., 2007, Djongyang et al., 2010)Thermal comfort is one of the most discussed indoor environment quality factor that influences occupant comfort and productivity(Roelofsen, 2015, Akimoto et al., 2010). It is described as *"state of mind which expresses satisfaction with the thermal environment"* (ASHRAE, 2004). Literature suggests that temperature change within the 18 °C–30 °C range can influence the occupant performance in office tasks like reading, typing and learning performance. The temperature 21 °C–25 °C is suggested to be a stable temperature range for office productivity. Occupant productivity decreases by 2% per 1 °C increase in temperature in the range of 25 °C–30 °C (Seppanen et al., 2003, Seppänen and Fisk, 2006). Personal control over thermal conditioning systems helps to raise occupant satisfaction, but they may result in energy wastage due to energy wastage (Tetlow et al., 2012). It is not necessary that a comfortable occupant would be highly productive (Fisk, 2000b). There is a need to investigate further into this area.
3. **Lighting and Daylighting** (Hopkinson et al., 1966, Alrubaih et al., 2013, L Edwards, 2000)Daylighting influences our day to day tasks. Daylighting is considered to the best source of light for human visual comfort. It has a positive effect on people behaviour(Li and Lam, 2001). Lighting in the built environment has a high share in energy consumption. The energy consumption of lighting in offices ranges from 25 to 40% in the USA and about 33% in Spain (Pérez-Lombard et al., 2008). Organisations that pay attention to the importance of daylighting in their workplaces gains from a reduction in energy bills and an increase in occupant productivity (Yang and Nam, 2010). Studies report that buildings with higher daylight help to reduce absenteeism and increase attendance (Romm and Browning, 1994). However, the designers also need to cater the glare problems faced due to excessive sunlight and or indoor lighting (Zhang and Barrett, 2012). Buildings need to have a real-time approach to harvest maximum sunlight and use lighting design strategies such as active dimming and switching control to avoid glare problems.
4. **Noise and Acoustics** (Sundstrom et al., 1994, Banbury and Berry, 2005, Mui and Wong, 2006) Noise and Acoustics have high relevance in work environment design. Bad acoustic and noise performance can lead to dissatisfaction with the office environment and reduced employee performance (Toftum et al., 2012). Continuous and prolonged noise at higher levels can induce and increase stress levels over time. It can lead to higher levels of blood pressure and stress (Evans et al., 1998). There are two types of noises; external and internal. External noise can be avoided using various design and material strategies in building envelope design. Design strategies involve using various office design techniques and material selection in indoor environment design to reduce internal noises such as co-worker conversations, machine sounds.
5. **Office Layout** (Brill et al., 1985, Laing et al., 1998, Cabe, 2005, Haynes, 2009) Office layout has a high level of influence on an organisation's work process, employee performance and behaviour (Haynes, 2008a, Haynes, 2007, Haynes, 2009). The design features such as seating density, proximity and privacy influence our work pattern and performance (Lee, 2010) The physical environment of a workplace influences the recruitment, retention and productivity of the organisation, thus affecting organisation's business capability and success (Wheeler and Almeida, 2006). The literature highlights the discussion of different office layouts and their effect on occupant productivity. Open plan office and cellular offices have been discussed with their positive and negative aspects (Stallworth and Kleiner, 1996; Haynes, 2008b). The office layout and design should be approached uniquely and handled according to organisation's work process and nature of work. Currently, office layout is not part of any green building guidelines.
6. **Biophilia and Views** (Heerwagen and Orians, 1984, Grinde and Patil, 2009, Heerwagen, 2009, Green, 2012) Humans are highly responsive to nature and its forms, patterns (Nabhan et al., 1993). We have an innate tendency towards any living form (Wilson, 1984). Humans have a higher level of happiness and well-being in the natural environment (MacKerron and Mourato, 2013). Occupant satisfaction and productivity are highly influenced by the presence of greenery inside the office environment and views of nature (Heerwagen and Orians, 1984, Heerwagen, 2003, Kellert et al., 2008). The introduction of Biophilia and nature's views can

lead to a reduction of 10% in workers' absenteeism in an office environment (Elzeyadi, 2011). With mass developments and increasing urban spaces, Biophilia has a significant role to play in achieving occupant comfort, satisfaction and productivity.

The IEQ factors such as thermal comfort, indoor air quality, lighting and daylighting, quality of views and acoustic performance are present in GSAS and other green building guidelines. However, these are mainly related to the mechanical aspects of indoor environment quality assessment. There is no direct effort to cater occupant satisfaction and promote occupant productivity. The green building rating systems' criteria focusing occupant health may or may not affect occupant productivity. It is an opportunity to analyse IEQ factors and criteria in green building rating with a focus on occupant productivity. This study focuses on GSAS building rating system to outline to the opportunities for updating its criteria and submittals to focus occupant productivity.

The next section presents the GSAS analysis based on IEQ factors identified above. It presents the criteria and submittals that focus on the each of the IEQ factors.

4. GSAS analysis: Desktop study

This section investigates the Global Sustainability Assessment System (GSAS) rating system and its categories to identify criteria focusing the six physical environmental factors identified above.

Following the identification of the six IEQ factors, the research team conducted a desktop analysis to analysis GSAS rating system and its focus on these IEQ factors (Al Horr et al., 2016c).

GSAS is divided into eight categories (Fig. 7). The indoor environment has its category with 16% weightage. However, this document analyses all the categories in GSAS to identify criteria related to the identified six IEQ factors affecting occupant productivity.

4.1. Indoor air quality

The study analysed GSAS rating system to identify criteria and submittals focusing indoor air quality. The indoor air quality is covered by two categories in the GSAS guidelines. In energy category, criterion (E.5) focuses on the nitrogen and sulphur gases in the indoor environment. The criterion defines two submittals with 2.05% weightage of the overall scoring. The indoor environment category has four criteria focusing indoor air quality. These criteria focus on ventilation design (IE.2, IE.3) of the building and indoor air pollutant source (IE9, IE.10) in the buildings. These four criteria have 16 submittals with 7.12% weightage of the overall scoring. Overall indoor air quality has 15 points with 9.17% weightage of the overall scoring.

4.2. Thermal comfort

Thermal comfort is an important aspect of indoor environment quality. Thermal comfort is a major IEQ factor that affects occupant productivity. It also GSAS system has one dedicated criterion for thermal comfort in the indoor environment category. The criterion outlines six submittals with 1.57% weight of the total score. Energy category has energy demand performance (E.1) criterion that focuses on the energy efficiency of the building for thermal comfort. This criterion has nine submittals with 7% weightage of the overall scoring. The site category has heat island effect (S.7) criterion focusing on the heat island effect generated by the neighbouring building. Heat island effect also influences the thermal comfort of the occupants. This criterion has six submittals with 0.78% weightage of the overall scoring. Overall, thermal comfort aspect has nine points and 9.35% weightage of the total scoring.

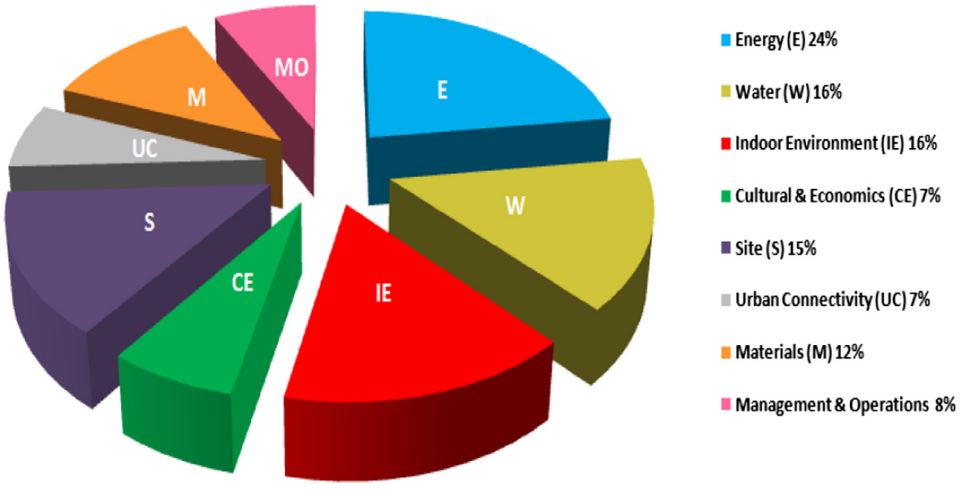

Fig. 7. GSAS categories and weights V2.0.

4.3. Lighting and daylighting

Indoor environment category covers lighting and daylighting. There are three criteria focusing lighting and daylighting aspect of the indoor environment. These are illumination levels (IE.4), daylight (IE.5) and glare control (IE.6). They have 15 submittals with nine points and 4.57% weightage of the total score.

4.4. Noise and acoustics

Three GSAS categories cover noise and acoustics aspect. Urban connection category has an acoustic condition (UC.6) criterion that highlights submittals focusing urban level acoustic conditions around the site. Noise pollution (S.9) criterion under site category identifies submittals focusing neighbouring noise pollution sources and design mitigation strategies. Acoustic quality (IE.8) criterion under indoor environment category identifies seven submittals focusing noise sources, acoustic quality of material used in the building and acoustic analysis in and around the building. Noise and acoustic factor has nine points and 2.21% weightage of the total score.

4.5. Office layout

There is no criterion focusing office layout in the GSAS commercial building guidelines.

4.6. Biophilia and views

The GSAS system has views (IE.7) criterion under indoor environment category that highlights five submittals focusing outside views from the indoor environment of a building. The criterion has 1.37% weightage of the total score. Biophilia has two elements, the Biophilia features outside the building and inside the building. GSAS building guidelines system indirectly addresses the Biophilia features outside the building in the site category. The habitat preservation (S.3) and Vegetation (S.4) criteria outline eight submittals highlighting strategies for preserving local ecosystem and vegetation and landscape design for the site. These criteria have six points with 1.68% weightage of the total score. GSAS system does not recommend any indoor Biophilia design strategy. Overall, Biophilia and views aspect has nine points with 3.05% weightage of the total score.

This research study has analysed the current GSAS green building rating system and its categories along with various indoor environment quality factors that affect occupant productivity. The study establishes the implicit links between the indoor environment quality factors and GSAS ratings. It identified different GSAS category and criteria focusing each of the six indoor environment quality factors. Indoor air quality and thermal comfort have the highest weightage allotment among the eight IEQ factors. Indoor environment quality and thermal comfort have a high impact on occupant comfort and productivity, and they are well addressed in the GSAS. The medium impact IEQ factors like lighting & daylighting, noise & acoustics, and Biophilia and view have been taken into account carefully as well. However, the study indicates that office layout can be addressed more appropriately. GSAS can include criteria on office design to reduce disruption and distraction caused due to inefficient office layout in the office buildings. Overall, the analysis present that GSAS guidelines have 28.35% weightage towards both indoor and outdoor environment aspects that influence occupant productivity (Table 1). About One-third weightage addressed directly or indirectly towards environment quality factors indicate that GSAS rating system has a well-balanced approach towards occupant comfort and productivity.

5. Survey results

The survey and workshop discussion topics were developed on the basis of above GSAS analysis. The participants were requested to share their experience and perspectives about the individual IEQ factors and how well it has been covered in GSAS to improve occupant productivity. The question asked was:

- In your experience/perception, how do occupants in a GSAS rated building feel about effects of indoor environment quality on their productivity along the parameters listed below?

The occupants were given five-point scale to answer the 11 aspects of six IEQ factors. The scale ranged included very negatively, negatively, neutral, positively and very positively. The aspects questioned were: Natural Ventilation, Mechanical Ventilation, Low-emitting materials, Indoor chemical and pollutant source control, and thermal comfort, acoustic quality, and daylight, Glare control, views, office layout and closeness to nature.

5.1. Indoor air quality

The survey requested participants to share their experience on effects of current indoor air quality criteria on occupant productivity in GSAS rated buildings (Fig. 8). We asked the questions related to criteria that were identified both in the literature review and GSAS analysis. Natural ventilation, mechanical ventilation, low-emitting materials, and indoor chemical and pollutant source control credits fall into indoor air quality factor.

- Indoor Chemical and Pollutant Source control: The survey indicates that almost 50% of the participants believed that occupants feel positive about the chemical and pollutant control in GSAS buildings. 30% of the participants shared a neutral response. Overall, about 60% of the response is positive (positive and very posi-

Table 1
GSAS analysis: desktop study.

IEQ Aspect	Category	Criteria	Submittals	Total score	Weightage
Indoor Air Quality	2	5	15	15	9.17%
Thermal Comfort	3	3	21	9	9.35%
Lighting and Daylighting	1	3	15	9	4.57%
Noise and Acoustics	3	3	16	9	2.21%
Office Layout	Nil	Nil	Nil	Nil	Nil
Biophilia & Views	2	3	13	9	3.05%
Total			92	66	28.35%

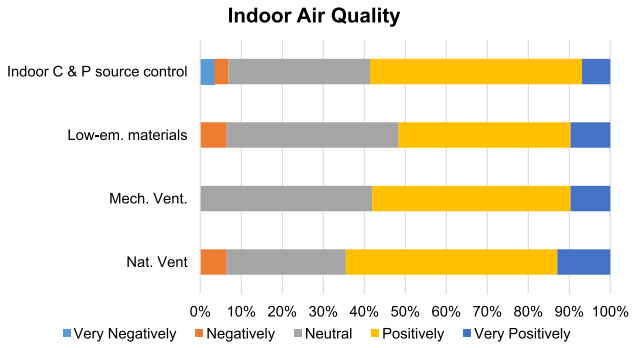

Fig. 8. Survey response – indoor air quality.

tive). It indicates that, in GSAS professionals' design and delivery experience and occupant feedback, the GSAS rated buildings have good measures and submittal to control indoor chemical and pollutant sources.

- Low-Emitting Material: The VOC credits are focused on ensuring that VOC (Volatile Organic Compound) content is low and controlled in an indoor environment as it reduces air quality and can cause damage to human health, productivity and environment. The survey response indicates that participants are 45% neutral, 40% positive and 10% very positive. There is roughly 5% negative response. Overall it represents that 50% of the participants believe that occupants feel positive or very positive about the measures placed to control low-emitting material.
- Mechanical Ventilation: The survey indicates that about 45% respondents feel neutral about mechanical ventilation and rest of 55% believe that mechanical ventilation in GSAS accredited buildings has a positive or very positive effect on occupant productivity.
- Natural Ventilation: The credits focused on natural ventilation aim to achieve certain natural ventilation based on floor plans and occupancy calculations. The survey indicates that about 5% respondents feel negative, 30% neutral and 65% believe that natural ventilation in GSAS accredited has a positive and very positive effect on occupant productivity.

GSAS analysis and survey results indicate overall positive results. Indoor chemical and pollutant source control, low-emitting material and natural ventilation have around 5–10% negative feedback from the survey. The research team would further analyse the data and identify the potential step forward to improve these aspects.

5.2. Thermal comfort

The participants were requested to share their experience on the effects current thermal comfort criteria on occupant productivity in GSAS rated buildings. The response highlights that about 30% participants are neutral and 70% of the response is positive (positive and very positive) (Fig. 9). It reflects that majority of participants believe that current thermal comfort credits positively influence occupant productivity in GSAS rated buildings.

5.3. Lighting and daylighting

The participants were requested to share their experience on effects of current lighting and daylighting criteria on occupant productivity in GSAS rated buildings. Glare control, daylight and illumination levels credits represent the lighting and daylighting factor (Fig. 10).

- Glare control: Doha has a sub-tropical desert climate. There is ample sunlight, but the buildings face many glare issues due to the climate. The survey response indicates that 5% participants feel negative, 45% feel neutral, and 50% feel positive (positive and very positive) about the glare control criteria and its effects on occupant productivity in GSAS rated buildings.
- Daylight: The survey response shows that 5% participants feel very negatively, 25% are neutral, and 70% of the participants are positive (positive and very positive) about the daylight criteria, and its effects on occupant productivity in GSAS rated buildings.

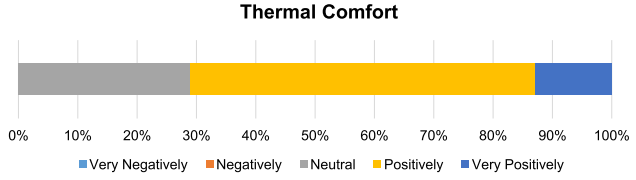

Fig. 9. Survey response – thermal comfort.

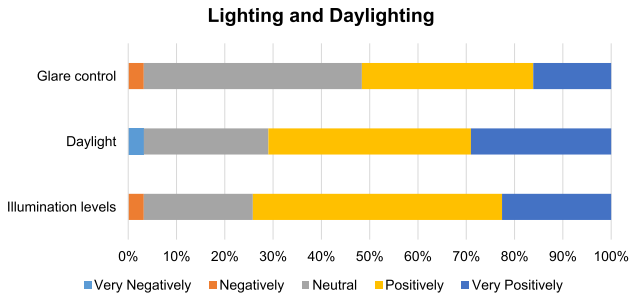

Fig. 10. Survey response – lighting and daylighting.

- Illumination levels: The survey response highlights that 5% participants feel negative, 20% are neutral, and 75% believe that current illumination level criteria have a positive influence on occupant productivity in GSAS rated buildings.

The survey of criteria focusing lighting and daylighting factors outlines a convincing positive response. However, some participants have been neutral about the impact of these criteria on occupant productivity. It indicates that these participants are not sure about the direct relationship between the criteria and occupant productivity.

5.4. Noise and acoustics

The participants were requested to share their experience on effects of noise and acoustics criteria on GSAS rated buildings. The survey response indicates that 5% participants feel negative, 40% feel neutral and 55% feel positive (positively and very positively) about the effects of noise and acoustics criteria on occupant productivity in GSAS rated buildings (Fig. 11).

5.5. Biophilia and views

The participants were requested to share their experience on effects of criteria related to Biophilia (nature) and outside views on occupant productivity in GSAS rated buildings (Fig. 12).

- Views: The survey response indicates that about 5% participants feel negative, 25% feel neutral and 70% participants feel positive (positively and very positively) about the impact of criteria related to views of nature on occupant productivity. Doha's climatic conditions limit the growth potential of plantation and nature. The response indicates that landscaping in GSAS projects has achieved positive results.
- Closeness to nature: The survey response shows about 13% negative response. The neutral response is 25%, 62% participants feel positive and very positive about the impact of criteria related to closeness to nature/biophilia on occupant productivity in GSAS rated buildings.

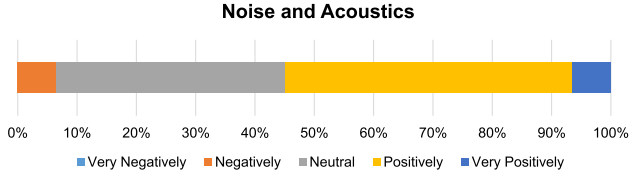

Fig. 11. Survey response – noise and acoustics.

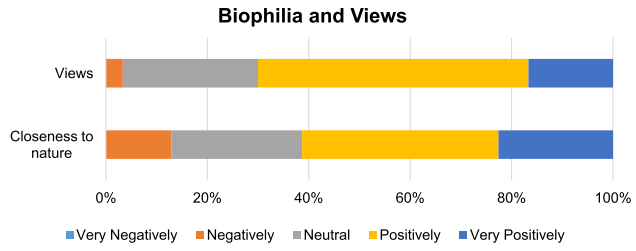

Fig. 12. Survey response – biophilia and views.

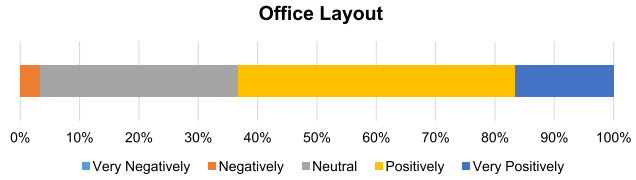

Fig. 13. Survey Response – office layout.

5.6. Office layout

The participants were requested to share their experience on effects of office layout on occupant productivity. Currently, there are no criteria and credits in GSAS rating system that focus on office layout. The participants were aware of it. The facilitators of the workshop requested participants to fill the survey as per their industry experience (Fig. 13). The survey result indicates that 5% participants feel that there is a negative relation between office layout and occupant productivity. 30% participants feel that there is no relation between office layout and occupant productivity and 65% feel positive (positive and very positive) that office layout influences occupant productivity. The layout of every building is left to the interior designer or architects to design as per their design brief and contextual conditions. Every building is unique and requires a unique office layout as per client's needs and building floor plan and design. However, there is a need to investigate this factor more deeply to identify certain guidelines to ensure the findings from the research are applied to improve occupant productivity in office buildings rated by GSAS rating system.

6. Brainstorming session results

The workshop aimed to create a discussion environment between GSAS professional to address the issues of occu-

pant productivity, health and wellbeing and occupant behaviour. Six questions were formulated that were representative enough to provide an in-depth understanding and provide a future path to develop GSAS to address these issues. Out of six questions, four questions were related to occupant productivity. These are:

1) Based on your experiences, how has GSAS accreditation helped in employee productivity and wellbeing? If it has not, what do you think are the opportunities for facilitating future improvement that it is missing at the moment?
2) Are there any pre and post-occupancy evaluation tools that your organisation uses/could use to assess the impact on employee productivity and wellbeing by working in a GSAS environment?
3) How can you incorporate parameters on employee productivity & behaviour change into GSAS to make it not only building friendly but occupant friendly?
4) How have people reacted to/will react to working in a GSAS accredited environment? Are there any more opportunities or concerns?

The questions were distributed to get two responses for each question. The facilitators chose group leader for each group to manage time and group discussion for an hour. Later, the group leader presented the outcomes of the discussion.

Q1. Based on your experiences, how has GSAS accreditation helped in employee productivity and wellbeing? If it hasn't, what do you think are the opportunities for facilitating future improvement that it is missing at the moment?

The first question asked was assigned to two groups and initiate a discussion on the current focus of employee productivity and wellbeing in GSAS rating system. The participants were also asked to suggest the opportunities facilitate future improvement in these areas.

The highlights of the discussion are:

a) Credits favouring occupant productivity and wellbeing are present. However, some aren't practical.

GSAS provides credits for bike racks and bike paths. However, it is not practical because nobody cycles to work in Qatar due to harsh climate condition. These credits can be used for other practical, innovative ideas the suit the local climatic conditions.

b) Subjective physiological comfort (comfort may vary from person to person)

The participants strongly agreed on the issue of subjective comfort. It was highlighted that occupants in same work environment preferred different illumination levels. An example of using daylight sensors to maintain lighting level of 600 lx led to some complaints about the indoor lighting levels. Similarly, participants shared numerous instances when occupants felt hot and cold while sitting next to each other in an office environment. It highlights the complexity of comfort (thermal, visual) and subjectivity acts as a challenge to provide a comfortable and productive environment for everyone in the office. Similar issues were identified in the literature review, and this discussion confirms those findings. There is a need to investigate these issues further. It is highly applicable for multicultural and multi-ethnic workplaces. Participants suggested to increase individual control on building operation systems (Heating, ventilation and air conditioning systems). Individual controls on these systems may help to increase the perception of comfort.

c) Post-occupancy surveys

The participants suggested to mandate yearly post-occupancy surveys that focus on occupant comfort, productivity and health. Earlier, literature highlighted that buildings' actual performance might vary from as designed performance (Turner et al., 2008). The participants raised the same issue but also emphasised that age of the building and the way it is operated, could also lead to variation in building performance. It was suggested that a yearly post-occupancy survey should be developed and implemented to address this issue. A building's rating should be updated based on the post-occupancy survey results. It would provide a long-term disciplined solution for GSAS authority to ensure that certified green buildings are providing comfortable and productive indoor environment.

d) Focus on IEQ rather than energy and water

The discussions also led to issue that GSAS has many credits on energy and water consumption. Few participants expressed that there should be more focus towards IEQ rather than energy and water. However, the majority of participants agreed that there should be a balanced approach to ensure that GSAS rated buildings are sustainable for environment and occupants.

e) Greenery and employee friendly facilities

The participants expressed a strong need for GSAS rated building to provide more conducive and productive environment as compared to a non-GSAS building. It was suggested that adding greenery around and inside the building would help to improve productivity. GSAS currently focuses on green habitat and microclimate of the site in their rating system. The intent is towards environmental sustainability. The addition of greenery inside and around the buildings focusing floor plans and occupancy patterns would help to improve occupant health and productivity. Participants expressed that greenery in their projects has always been received positively by the occupants. Employee friendly facilities such as gym, coffee shop,

snacks/drinks vending machines, and child care facilities were also recommended to be included in GSAS rating system. Participants highlighted that these friendly facilities are not always in client's brief. Credits for these facilities would motivate clients to include these facilities in their design brief. These facilities would help to make the occupant more comfortable and indirectly influence their productivity and likeness towards the building.

f) Cultural diversity

The participants highlighted that Qatar has multicultural and multi-ethnic organisations and workplaces. It was recommended to include aspects of cultural diversity into the interior design of workplaces.

Q2. Are there any pre & post-occupancy evaluation tools that your organisation uses/could use to assess the impact on employee productivity and wellbeing by working in a GSAS environment?

The second question was aimed to collate any pre and post-occupancy evaluation tools that organisations could use to assess the impact of GSAS rated building's IEQ on occupant productivity and well-being.

The participants listed various methods that could help to assess the impact of IEQ on occupant productivity. The highlights of the discussion are:

a) Window analysis

Participants suggested that windows should be analysed for daylight and glare. The window analysis should be done to measure the daylight and if any glare is troubling the occupants. These analyses can be done both by calculations and occupant survey.

b) Noise

The participants suggested that continuously monitoring noise levels using sensors and managing internal noise sources such as printers; fax machines could help to assess the noise impact on employee productivity.

c) Amenities, accessibility and parking

The participants highlighted that location of the building also affects the occupants. They highlighted that access and distance to amenities affect the occupants' likeness towards the workplace. The parking is also one of the major aspects that help to outline the likeness of occupants. The majority of employees drive to work, and a covered parking at the office means a lot more in harsh climatic conditions. Accessibility of building from nearby parking or transport hub also helps to improve employees journey to work more comfortable, thus resulting in higher likeness towards the office and contribute in increasing occupant productivity. Analysis of these aspects helps to assess the impact of building's impact on occupant productivity.

d) Human Resource measures

The participants highlighted that various HR measures could help to assess employee productivity. For instance, Absenteeism can be analysed and compared between two offices of the same organisation. Similarly, time spent on work (timesheet) can also be analysed to outline the difference in occupancy patterns between two offices of the same organisation. These analyses could highlight different attendance and work occupancy patterns.

Q3. How can you incorporate parameters on employee productivity & behaviour change into GSAS to make it not only building friendly but occupant friendly?

The highlights of the discussion are:

a) Mandate periodic employee survey to assess employee satisfaction and productivity.

It is difficult to address occupancy issues in the design stage. The occupant's behaviour, comfort and productivity are only highlighted in the operation phase. Employee feedback using survey is highly important to develop a better understanding of IEQ and improve design for future buildings. The participants strongly recommended mandating periodic employee satisfaction and productivity survey in GSAS rated buildings. It would help to map building's IEQ performance periodically. A continuous practice of feedback survey and assimilation of the results would help to continuously improve the GSAS rating system's IEQ performance and keep the occupant satisfied and productive.

b) Development of standards

The participants felt that standards on building design and operation should be updated. They believed that standards should be based on large-scale research outcomes. The standards developed in isolation do not work in practice. The standards should be developed in collaboration with industry professionals, clients and occupant to incorporate all the issues faced by each of the participants.

c) User education on building operation

Many participants expressed that building performance during operation is highly affected by bad operation activities. The users should be allowed to change the indoor environment control. However, the users should be educated about the building operating systems. It would help to inform the user on how building helps them in comfort. It would also help them to maintain their micro-environment much better. The knowledge about control systems would help to make user interaction with building and its system more positive leading to less occupant dissatisfaction and better building performance.

d) Stress

The participants believe that stress inducers if present in the indoor environment can reduce occupant comfort and productivity. The indoor environment should aim to reduce stress in a workplace situation. In most of the workplaces, stress due to work-related tasks is very common these days. There is a need to investigate different aesthetic and design features that help to reduce stress. These aesthetic and design features need to be included in the design brief and GSAS criteria for IEQ in office/workplaces.

Q4. How have people reacted to/will react to working in a GSAS accredited environment? Are there any more opportunities or concerns?

The highlights of the discussions are:

a) Positive reaction

The participants expressed that most of the responses in their experiences have been positive. They highlighted that occupants like working in a GSAS accredited environment.

b) Provide soothing environment in common spaces

The participants suggested that providing a soothing environment in common spaces using plants, water features and music would help to increase occupants' likeness towards the building environment. It was suggested that these features should carry credits to motivate clients to include them in the building design and brief.

c) Occupant suggestion and sharing success

The participants also suggest that occupants should be encouraged to provide suggestion to improve their indoor environment quality. The occupants can be motivated by using monetary or non-monetary awards. The successful ideas can be awarded, and success can be shared with the occupants using GSAS buildings. The participants also suggested forming a team of advocates help in motivating the occupants and in the movement of innovating ideas to GSAS administrators.

d) Amenities

The participants expressed that GSAS rating system would highly benefit from including criteria and credits related to amenities that makes occupants feel more comfortable and increase their likeness towards the building. Currently, no criteria are focusing the amenities and facilities.

The brainstorming session in the facilitated environment led to an insightful discussion with the participants. These discussions outlined the current GSAS rating system's positive aspects, shortcomings and future path for GSAS rating system to develop criteria to improve occupant comfort and productivity in GSAS rated buildings.

The next section presents the discussion and conclusion of the study.

7. Discussion & conclusion

This aim of the study was to analyse the current state of GSAS rating system and outline the criteria focusing occupant productivity. The study started with a review a wide range of literature to identify the indoor environment quality factors that influence occupant productivity in an office environment. The literature review identified six indoor environment quality factors. The GSAS rating system and its criteria were analysed against each of the identified IEQ factors to highlight the criteria covering those IEQ factors. The analysis highlighted that Indoor Air Quality and Thermal Comfort were the most covered IEQ factors. Lighting and Daylighting, Biophilia and views were also covered adequately. Literature review highlighted office layout as an important factor. However, GSAS rating doesn't have any criteria focusing office layout. The findings from the literature review and GSAS analysis were used to develop a survey and brainstorming questions for a workshop with GSAS professionals.

The survey findings reveal that the workshop attracted a sizable number of professionals. The participants were well qualified in with half of them with at least bachelor's degree and rest of them with Master's degree and some doctorate. The participant profile was also from a wide range of profile such as architect, green building consultant, project manager and operation managers. The participants' profile also exhibited a wide range of age group and experience. There were participants in early 20s with a fresh mindset and new approaches along the seasoned professionals with age above 50 yrs. and decades of industry experience. The majority of the participants belonged to the age group of 30–40 y. The participants had a wide spectrum of experience in different projects including residential, commercial, retail, healthcare, and rail and hospitality. The survey collated the participants' response to various indoor environment quality factors and criteria in GSAS buildings and their impact on occupant productivity. The survey covered 12 aspects in six indoor environment quality factors identified in the literature review and GSAS analysis. All the IEQ factors received positive response with few neutral participants. Analysing all the responses received for 12 aspects, we can advise that overall the survey received 5% negative (negatively and very negatively) feedback. About 33% participants responded with a neutral response. It indicates

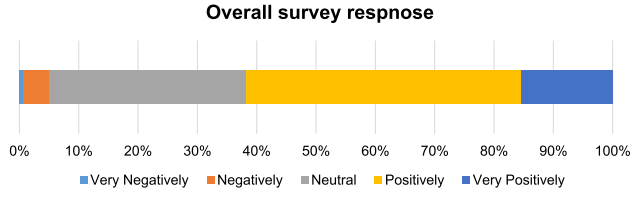

Fig. 14. Summary of survey result.

that, in participating professionals' experience, about one-third of the participants weren't sure about the impact of mentioned indoor environment quality criteria on occupant productivity in GSAS rated buildings. The overall positive response is about 62%, 46% positive and 15% very positive about the impact of these 12 aspects of six IEQ factors on occupant productivity in the GSAS rate buildings (Fig. 14).

The facilitated brainstorming sessions with GSAS professionals lead to discussions in three areas. Firstly, GSAS rating system's current performance in improving occupant productivity. The discussions highlighted that some measures and criteria indirectly contribute to improving occupant productivity. However, these criteria were developed to focus on some other aspect of sustainability. For example, the landscaping on the site and microclimate criteria were developed focusing environmental sustainability. However, greenery around and inside the building and views of nature designed as per occupancy plans can help to improve occupant productivity too. There is no direct intent to award credits for efforts to improve occupant productivity. Subjective comfort also acts as a practical problem in achieving thermal and visual comfort and productivity. Professionals shared experience about occupants' complaints on feeling cold and hot in the same area. The possible solution to explore is in the direction of promoting individual controls to users. The participants' felt that currently there is no assessment method in place to outline the performance of GSAS rated buildings in improving occupant productivity. Similar to energy performance, there is a need to develop assessment tools to measure occupant productivity. Also, Draft criteria which directly focuses on occupant productivity.

The second area of discussion was identifying ideas to develop methods for assessing occupant productivity. Many suggestions were related to various HR measures that can monitor occupant productivity periodically in two different offices of the same organisation. Methods like absenteeism, timesheet and occupancy patterns can be compared to highlight the difference in occupant productivity. A regular occupant survey enquiring about occupant comfort, satisfaction and productivity was also suggested to be incorporated in developing occupant productivity assessment method.

The third area of discussion was current GSAS limitations and opportunities to improve it. Participants highlighted about revisiting certain GSAS criteria and their practicality. The credits for bike paths and racks were criticised because the majority of employees drive to work in Qatar. Participants strongly emphasised on mandating periodic post-occupancy survey to help continuous monitoring of IEQ performance. Occupant education on GSAS and building operating system was requested to be part of handover and certification. It will ensure that users are aware of the implications of their interactions with the building. Participants also emphasised on introducing more greenery, both inside and outside the building area to improve occupant satisfaction and productivity. The introduction of credits for employee friendly facilities like childcare, gym, the coffee shop was also reported as potential opportunity to improve GSAS rating system. Participants also requested to include aspects of cultural diversity into design workplaces as Qatar has multicultural workplaces. Participants also provided innovative suggestions like providing a soothing environment in common spaces using plants, water and music. To get more ideas to improve GSAS, it was suggested to motivate GSAS buildings' occupant in providing ideas and sharing success with them to motivate them further.

This paper has presented a comprehensive analysis of GSAS rating system and its current status focusing occupant productivity. The contribution of this paper is that it highlights current gaps and opportunities to update GSAS rating system to include occupant productivity criteria. The paper has also listed potential assessment method for measuring occupant productivity. It has also presented a detailed methodology and steps to analyse a building rating system for other researchers.

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